IOWA DEPARTMENT
OF NATURAL RESOURCES
SOURCE WATER PROTECTION PROGRAM

SITE INVESTIGATION REPORT
DUNLAP, IOWA

Prepared by
IDNR Contaminated Sites Section

Iowa Department of Natural Resources
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PROJECT SUMMARY

A Source Water Protection Site Investigation (SWPSI) was conducted for the community of Dunlap, Iowa through the Iowa Department of Natural Resources (IDNR) Iowa Code Section 28E.2 Agreement. Contributors to this investigation include the City of Dunlap Community Source Water Protection team, the Contaminated Sites Section-IDNR, and the Iowa Geological Survey-IDNR.

In April 2009, the Iowa Geological Survey completed a Source Water Protection Phase I site investigation for the City of Dunlap. The Phase I utilized existing information to evaluate the Dunlap public water supply's active wells, general aquifer characteristics, susceptibility to contamination and identify potential contaminant sources. The Phase I identified two active wells serving the community of Dunlap. The wells are city well #3, which is 97 feet deep and city well #4, which is 105 feet deep. Both wells are completed in the Boyer River alluvial aquifer and deeper Dakota bedrock aquifer. The Boyer River alluvial aquifer is the sole focus of this SWPSI because it is considered to be highly susceptible to contamination. The source water area for these wells was delineated by a hydrologic model that defines time-of-travel capture zones around the active wells. Neither city well has exceeded the EPA nitrate drinking water standard (10 mg/L), however the concentration of nitrate is consistently over half the drinking water standard and has demonstrated an increasing trend. City well #3 and #4 were drilled to replace two other wells (city well #1 and city well #2) that were contaminated by nitrate over the drinking water standard.

The three primary objectives of the SWPSI were to determine how the alluvial aquifer distributed, how ground water in the alluvial aquifer is affected by pumping and is there a nitrate point source responsible for the nitrate? The investigation activities to address these objectives consisted of measuring electrical conductivity to determine the depth and thickness of alluvial aquifer and sampling and analyzing raw ground water for nitrate to characterize water quality within the estimated 2 year capture zone.

Thirty-three ground water samples were collected and analyzed for nitrate from ten locations within the estimated 2 year capture zone. Soil and ground water samples were also analyzed for petroleum in the vicinity of a non-compliant above ground (diesel) fuel storage tank (AST) that was discovered during the course of the investigation. Nitrate was detected above the drinking water standard at two locations but the overall result of the SWPSI was inconclusive in identifying a point source for the nitrate observed in the city wells. Petroleum was not detected in ground water but was detected in soil near the ASTs at a level below the IDNR Underground Storage Tank program Tier 1 standard of 3,800 mg/kg for soil leaching to ground water.

I.) INTRODUCTION

Nitrate contamination in drinking water supplies is categorized into two general source types: non-point source, which is generally the result of normal surface application of commercial fertilizer or manure on crops, and point source, that may include but is not limited to major fertilizer spills or numerous small releases from storage and handling facilities. The level of nitrate in the city wells #3 and #4 has not exceeded the EPA drinking water standard (10 mg/L), however an increasing nitrate trend was the primary reason the IDNR Source Water Protection Program selected Dunlap for a SWPSI. The concentration of nitrate has reached 7 mg/L where it has stabilized for several months. Two other city wells (#1 and #2) were taken out of service due to nitrate contamination from a point source and there is concern that this scenario could be repeated for city wells #3 and #4.

The focus of the SWPSI was on Dunlap city well #3 and city well #4. These wells have a maximum combined pumping rate of around 500 gallons per minute. They are separated by less than 100 feet and their combined pumping effect is essentially to act as single pumping center. The wells are 97 feet and 105 feet deep respectively and are dual completion wells that draw water from both the Boyer River alluvial aquifer and the deeper Dakota (sandstone) bedrock aquifer. The Boyer River alluvial aquifer was designated as highly susceptible to contamination by the Geological Survey Source Water Protection Phase I investigation. The deeper Dakota aquifer is considered less susceptible because of better protection from contamination provided by overlying geologic deposits. The source water area delineated for city well #3 and city well #4 is based on a hydrologic model that defines time-of–travel capture zones around the active wells. These capture zones are divided into 2, 5 and 10 year time of travel designations. The SWPSI only evaluated water quality of the Boyer River alluvial aquifer within the area of the estimated 2 year capture zone (figure 2) because contaminants in this zone have the shortest travel time to the wells, and therefore, source water protection strategies implemented there have the greatest potential for protecting or improving drinking water quality. The deeper Dakota aquifer was not evaluated due to limitations of the investigation and inaccessibility of the aquifer to evaluation.

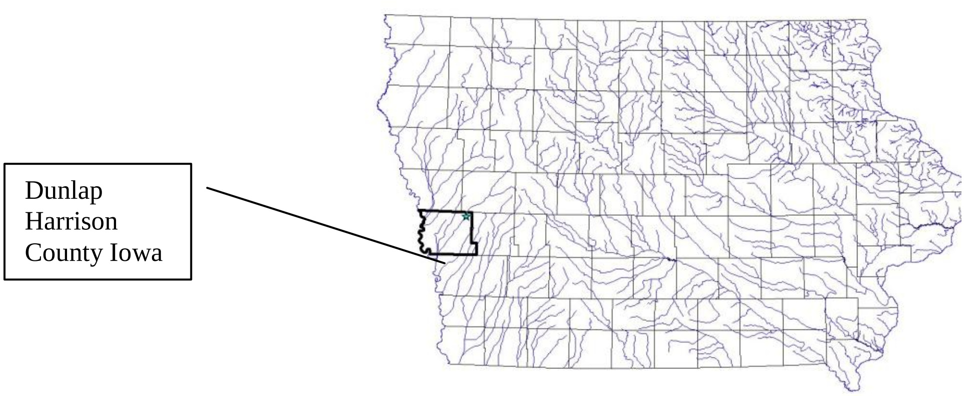


Figure 1: Project Location Northeast Harrison County, Iowa

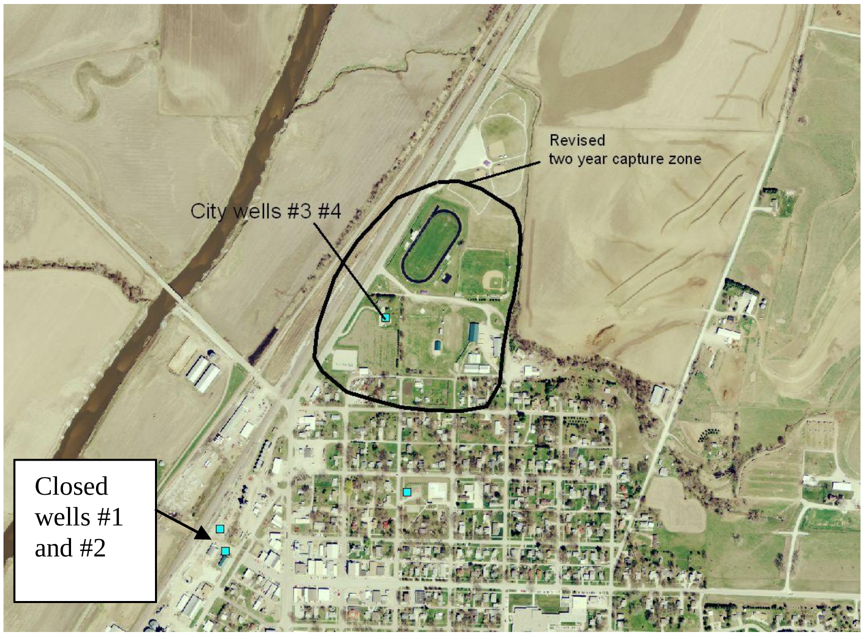


Figure 2: Estimated 2 Year Capture Zone

II.) PROJECT LOCATION AND GEOLOGIC SETTING

The community of Dunlap is located in extreme northeastern Harrison County, Iowa along the Boyer River (figure 1). The general geologic setting of the area is characterized by loess (wind-blown silt) covering eroded glacial clay uplands that are underlain by deeply eroded Cretaceous Dakota bedrock (figure 3). Soil in the area is described as the Kennebec-McPaul-Nodaway Soil Association, which is a common soil series along the Boyer River valley. The transition between the river alluvium and the upland is dominated by alluvial fans. The Boyer River alluvial deposits are characterized by coarse grained glacial sand and gravel at depth with silt and clay sediment above. The coarse deposits are used locally as an aquifer by several communities in the Boyer River valley.

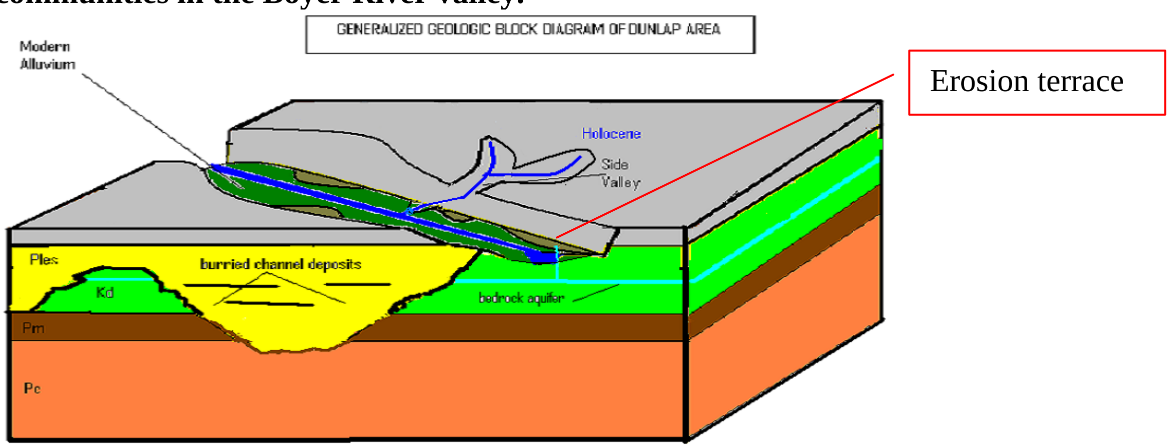


Figure 3: Block Diagram of Generalized Regional Geology

III.) CONTAMINANT SOURCES

There are several known sources and potential sources of ground water contamination in the Dunlap area within the estimated 2 year capture zone. Some were identified by the Phase I investigation, others discovered during the SWPSI. They include both point sources and nonpoint sources in and outside of the estimated 2 year capture zone (figure 4). The primary contaminant of concern for the SWPSI at Dunlap was nitrate however a potential petroleum point source was also discovered. A non-compliant above ground fuel storage facility was discovered 500 feet south of the city wells. Potential (localized) non-point sources of nitrate contamination within the estimated 2 year capture zone were identified during the SWPSI and include the Boyer Valley School District sports fields and the Dunlap fairgrounds. Sources of contamination outside the estimated 2 year capture zone were not the focus of this SWPSI but are worth noting as they could have an adverse affect on the aquifer. They include three fertilizer facilities currently under investigation as the possible point sources of nitrate that caused the closure of city wells #1 and #2. Potential nonpoint source of nitrate located outside the capture zone include the Boyer River and a 500 acre watershed located east of Dunlap where a livestock operation (potential point source of nitrate) is located along a creek that outlets to the Boyer River. The impact of the livestock operation on the creek was not determined. Similarly, the nitrate contribution from the creek to alluvial aquifer is also unknown. Limited surface water sampling of the creek was conducted monthly between June and October 2009 (excluding August) to characterize nitrate levels in the creek. Nitrate results for the creek were comparatively low at 0.29 mg/L, 3.0 mg/L, 2.2 mg/L and 1.1mg/L respectively. Individual laboratory results are in Appendix 1

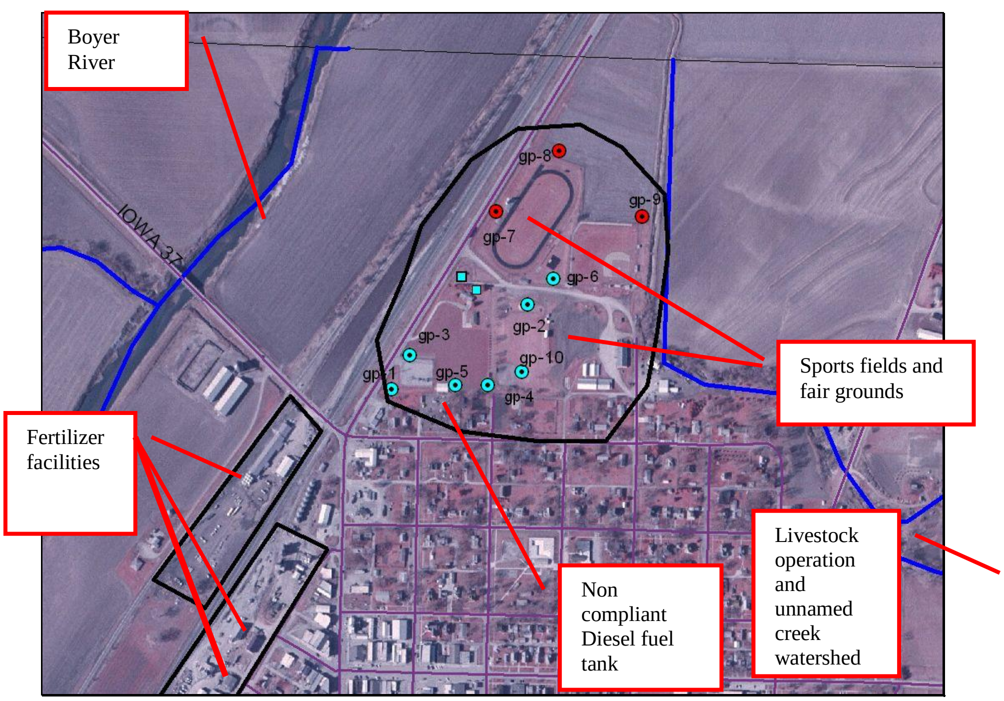


Figure 4: Project Area, Estimated 2 year capture zone and sample locations in blue

The Boyer River was considered as a potential nonpoint source of nitrate. To evaluate the potential impact from the river on the Dunlap water supply, historic water quality data for the Boyer River was evaluated. The nearest long-term surface water monitoring station for the Boyer River is located 20 miles south of Dunlap at Logan, Iowa. The long-term nitrate monitoring data presented in figure 5 (below) documents a steady ten year increase in nitrate from 6 mg/L in 1999 to 8 mg/L in 2009. Nitrate levels have fluctuated during that time from below 2mg/L to over 12 mg/L.

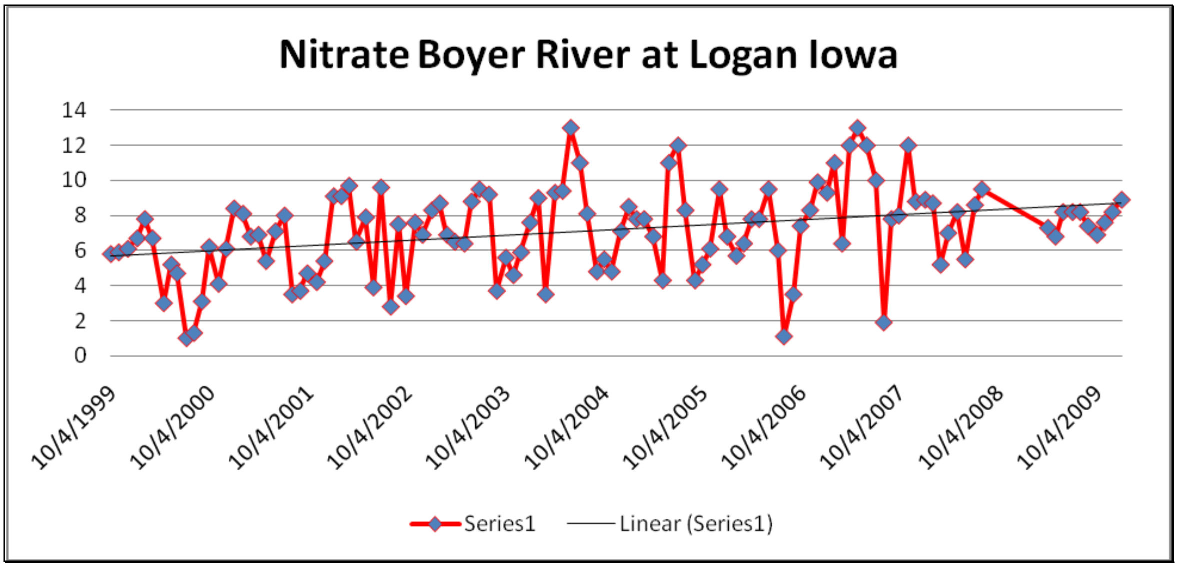


Figure 5: Boyer River water quality

The Boyer River may influence the nitrate level in Dunlap city wells because the wells are located within a few hundred feet of the river and under the right conditions may induce the flow of river water back to the wells (figure 6). This effect is referred to as induced surface water recharge. For further discussion of the potential influence of the Boyer River on city water quality see the attached report: *Use of Numerical Modeling to Evaluate the Quantity and Quality of Induced Surface Water Recharge for the City of Dunlap Prepared by Richard Langel, Geologist J. Michael Gannon, Hydrogeologist*

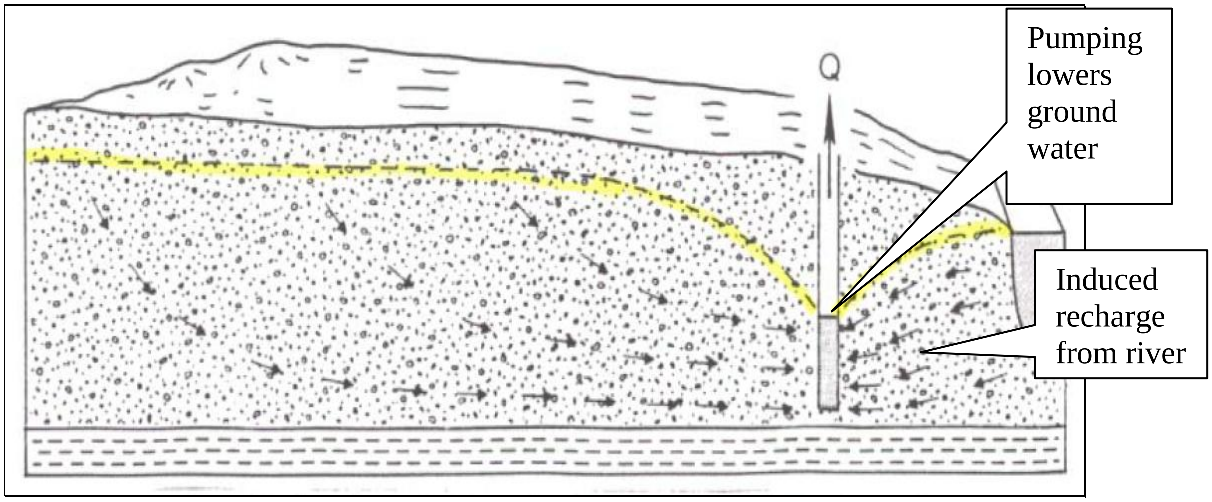


Figure 6: Induced flow

IV.) DUNLAP DRINKING WATER QUALITY HISTORY

To date, nitrate levels for Dunlap city wells #3 and #4 have never exceeded the EPA drinking water standard. From January 2002 until April 2007, well #3 was the only well in operation. During that time the level of nitrate held steady or slightly decreased from 6 mg/L to 4 mg/L. When well #4 went into service an increasing nitrate trend was noted. The reason(s) for the increase in nitrate are uncertain and was the primary reason for the conducting the Source SWPSI in Dunlap. As of July 2011 the combined nitrate concentration from wells #3 and #4 is holding steady at around 7 mg/L. Nitrate concentration in the city wells continues to be monitored monthly (figure 7).

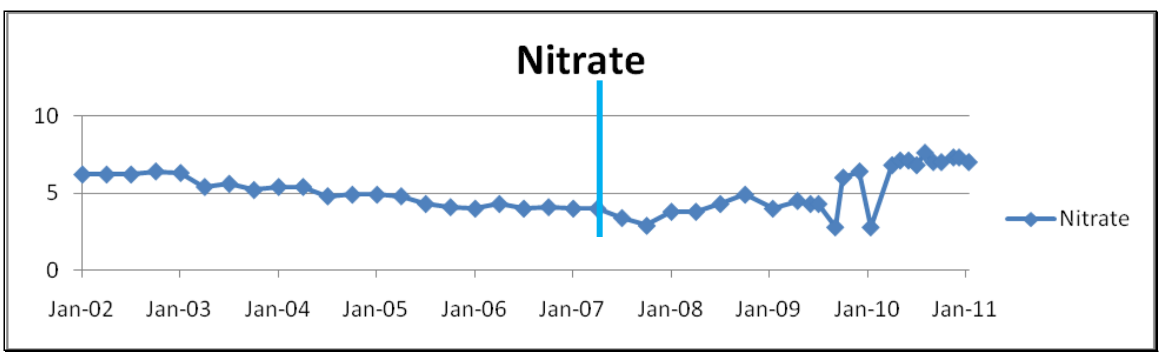


Figure 7: Nitrate concentrations for Dunlap drinking water

V.) RESULTS OF SWP SITE INVESTIGATION

The SWPSI addressed three basic objectives about the Boyer River alluvial aquifer and the water quality within it. Specifically, how is the aquifer distributed? How is ground water in the aquifer affected by pumping? Is the water quality adversely affected by contaminants from point sources and can they be identified?

Two field methods were employed to address these objectives. The first field method was electrical conductivity (EC) testing. Electrical conductivity equipment was used to confirm the depth and thickness of the Boyer River alluvial aquifer within the estimated 2 year capture zone. Geologic materials such as sand and gravel exhibit a lower electrical signal (conductivity) than do fine grained silts and clays and can be used to relatively differentiate aquifer from non-aquifer deposits. Three EC test holes were drilled to a depth of 60 feet. The first EC test location was next to the city wells. The purpose of this EC test was to create an EC profile for the aquifer at the city wells to compare the aquifer depth and thickness to two other locations within the estimated 2 year capture zone (figure 8). An EC value of <60 mS/m was equated to the alluvial aquifer at the city wells. The other two EC test holes were located approximately 500 feet east and north of the city wells. EC testing demonstrated similar aquifer characteristics (depth and thickness) to the east of the city wells but not to the north. A higher electrical conductivity (<60mS/m) was observed in the north test indicating greater silt and clay content and relatively poor aquifer definition. The EC profiles are in Appendix 2.

Figure 8: EC locations shown in green

Ground water sampling was conducted to determine if a point source of nitrate could be discovered. Thirty-three raw ground water samples were collected at ten randomly selected locations from three depth intervals (deep, intermediate and shallow). The sample locations were labeled GP-1 through GP-10. A subset of samples was field screened for nitrate by IDNR for comparison to laboratory results. All sample results (lab and field screened) are summarized in Table 1. Table data in highlighted in red exceed the nitrate drinking water standard and

data in yellow are equal to or greater than half the standard. Individual lab results for ground water listed in Appendix 1.

The deepest sampling interval was 56-60 feet, the intermediate depth interval was 44-48 feet deep and the shallow sample interval was 24-28 feet deep. Sampling from different depths intervals was to determine if nitrate concentrations varied with depth. The maximum nitrate concentration of 18 mg/L was observed in the intermediate depth interval at 36-40 feet deep in GP-9 located in the southeast corner of an athletic complex approximately 900 feet northeast of the city wells. No obvious point source was associated with this detection although the area exhibited stressed vegetation and may have periodic standing water that might cause nitrate loading. Samples from location GP-9 from the shallower depth of 24-28 feet were also analyzed for nitrate for comparison to the maximum nitrate concentration of 18 mg/L observed at that location in the 36-40 foot depth interval. The nitrate concentration at 24-28 feet was 5.0 mg/L.

The second highest nitrate concentration (13 mg/L) was observed in the intermediate depth interval at GP-7 located north of the city wells and west of the football stadium. No obvious point source was associated with this detection although there is a surface drainage ditch is nearby between the field and US Highway 30 that could carry significant surface run off. The third highest nitrate detection (6.6 mg/L) was detected at GP-8 in the shallow depth interval in a grassy area north of the city wells and the football field. The fourth highest concentration of nitrate (5.0 mg/L) was again at sample location GP-9 at a shallower depth interval and was confirmed by a duplicate sample (GP-9d). Samples from location GP-10 from 24-28 feet were analyzed for possible elevated residual nitrate from periodic storage of animal manure on the fairgrounds during county fair events however no residual nitrate impact from manure was indicated.

VI.) SUMMARY OF NITRATE AND PETROLEUM DETECTIONS

The general picture that emerges from the distribution of nitrate concentrations in ground water within the estimated 2 year capture zone is one of good water quality. Elevated nitrate concentrations appear to be limited to the shallow (36-40 ft.) and intermediate (44-48 ft.) depth intervals. Sample locations GP-1 through GP-5 were below <1 mg/L or not detected in all depth intervals. Nitrate was detected between 1 and 2 mg/L in at least one depth interval at GP-6 through GP-10. Nitrate concentrations between 1 and 2 mg/L are consistent with natural background levels. Nitrate levels >5mg/L that is considered above natural background levels were detected at only three sample locations (GP-7, GP-8 and GP-9). Nitrate exceeded the drinking water standard of 10mg/L at two locations (GP-7 and GP-9) located north and northeast of the city wells. Overall, the nitrate distribution in ground water appears more typical of non-point source contamination.

Eight ground water samples and one soil sample were collected from the vicinity of the non compliant fuel storage tank and analyzed for petroleum as diesel fuel. Diesel fuel was not detected in any of the ground water samples, however diesel fuel was detected in a soil sample at 1,900 mg/kg at location GP-5. The concentration detected was below the IDNR Underground Storage Tank program Tier 1 standard of 3,800 mg/kg for soil leaching to ground water. Laboratory results for soil and ground water analyses for petroleum are in Appendix 1.

Table 1: Summary of ground water analyses by State Hygienic Laboratory for nitrate and BTEX analysis and field comments. (*) no sample (ND) not detected

Sample /Interval	Depth (ft.)	Nitrate (Mg/L)	BTEX (mtBE)	Field comments
Gp-1				Next to MEC substation
Shallow	24-28	*	ND	
Intermediate	44-48	ND	ND	Field Hach results: 1.37 mg/L nitrate
Deep	56-60	ND	ND	Field Hach results: <0.5 mg/L
Gp-2				Next to helipad, easy to 36 ‘ then firm
Shallow	36-40	0.53	*	
Intermediate	44-48	0.99	*	Field Hach results: 1.48 mg/L nitrate
Deep	56-60	ND	*	
Gp-3			*	Refusal @ 58 (bedrock)
Shallow	36-40	ND		
Intermediate	44-48	ND	*	
Deep	56-60	ND		
Gp-4				East end of alley
v. shallow	24-28	*	ND	
Shallow	36-40	ND	*	
Intermediate	44-48	ND	*	
Deep	56-60	ND	*	Field Hach results: <0.5 mg/L
Gp-5				Next to ASTs, soil sample, stressed veg.
v. shallow	20-24	*	ND	
Shallow	36-40	ND	ND	
Intermediate	44-48	ND	ND	
Deep	56-60	ND	ND	
Gp-6				Next to high jump pit
Intermediate	44-48	1.6	*	Field Hach results: 1.75 mg/L nitrate
Deep	56-60	1.8	*	
Gp-7				Behind football grand stands
Intermediate	44-48	13	*	
Deep	56-60	ND	*	
Gp-8				South of softball complex
Shallow	36-40	6.6	*	
Intermediate	44-48	1.0	*	
Deep	56-60	ND	*	
Gp-9				North of baseball field)
v. shallow	24-28	5.0	*	
Shallow	36-40	18	*	
Gp-9 dup shallow	24-28D	5.6	*	
Intermediate	44-48	4.6	*	
Deep	56-60	ND	*	
Gp-10				Fair grounds, dark color, organic odor
v. shallow	24-28	0.20	*	
Shallow	36-40	ND	*	
Intermediate	44-48	1.6	*	
Deep	56-60	ND	*	

VII.) CONCLUSIONS

The SWPSI did not identify a point source for nitrate within the estimated 2 year capture zone. Three ground water sample locations in the vicinity of the Boyer Valley sports complex had elevated nitrate but have not been attributed to a source. Several other potential (localized) nonpoint sources for nitrate were also identified during the SWPSI.

The results of EC testing indicated good aquifer presence to the east of the city wells based on similar EC test results found at the city wells. Less developed aquifer conditions were indicated to the north.

Nitrate was not detected in the lowest depth sample intervals of 56-60 feet at any sample location. Nitrate concentrations appear to be limited to the shallow 36-40 ft and intermediate 44-48 ft depth intervals. The maximum nitrate concentration observed was 18 mg/L at location Gp-9 just north of the baseball field. Lesser nitrate concentrations (between 5 and 10 mg/L) were observed west of the football field and south of the city softball complex.

A non-compliant diesel AST was discovered within the estimated 2 year capture zone. Petroleum was not detected in any of the ground water samples however it was detected at 1,900 mg/kg in soil. This concentration is below the IDNR Underground Storage Tank program Tier 1 standard of 3,800 PPM for soil leaching to ground water. It would appear that fuel has not yet been spilled in sufficient volume to saturate soil and cause leaching to ground water. The substandard facility was reported to the state fire marshal's office.

VIII.) RECOMMENDATIONS

- **Evaluate known point sources and non-point sources of nitrate near and within the estimated 2 year capture zone to determine if it is possible prevent nitrate spills or reduce nitrate (field) applications.**

- **An evaluation should be conducted the of surface water nitrate load coming from the unnamed creek watershed that drains into the estimated 2 year capture zone**

- **The above ground fuel tanks located north of Clinton Street should be properly re-constructed with appropriate fuel storage, dispenser, and spill control features to meet requirement of state fire marshal or be removed from the estimated 2 year capture zone.**

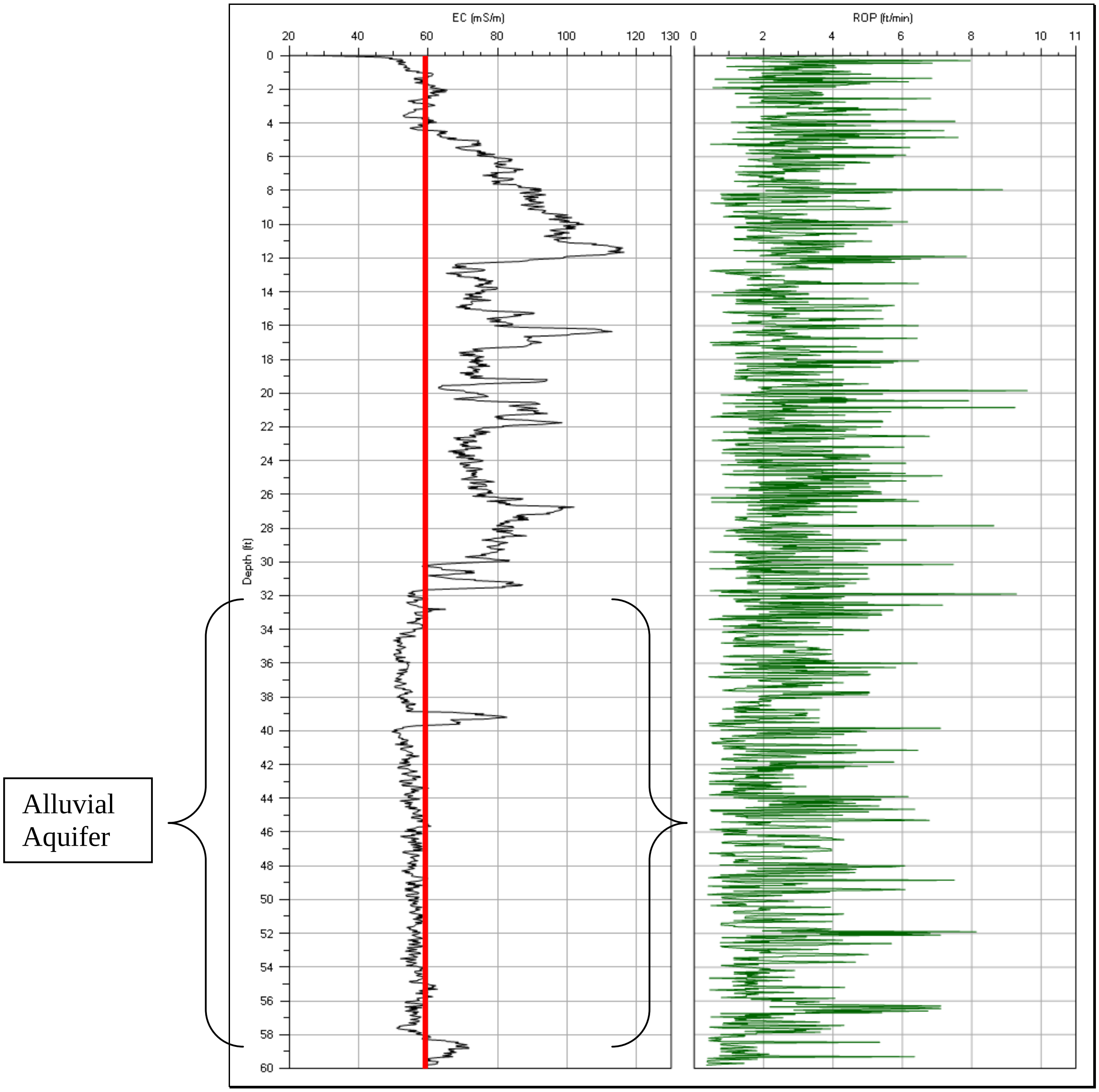
- **The Dunlap Community Source Water Protection team should initiate an information & education program for residential fertilizer and lawn management within the estimated 2 year capture zone**

Appendix 1:

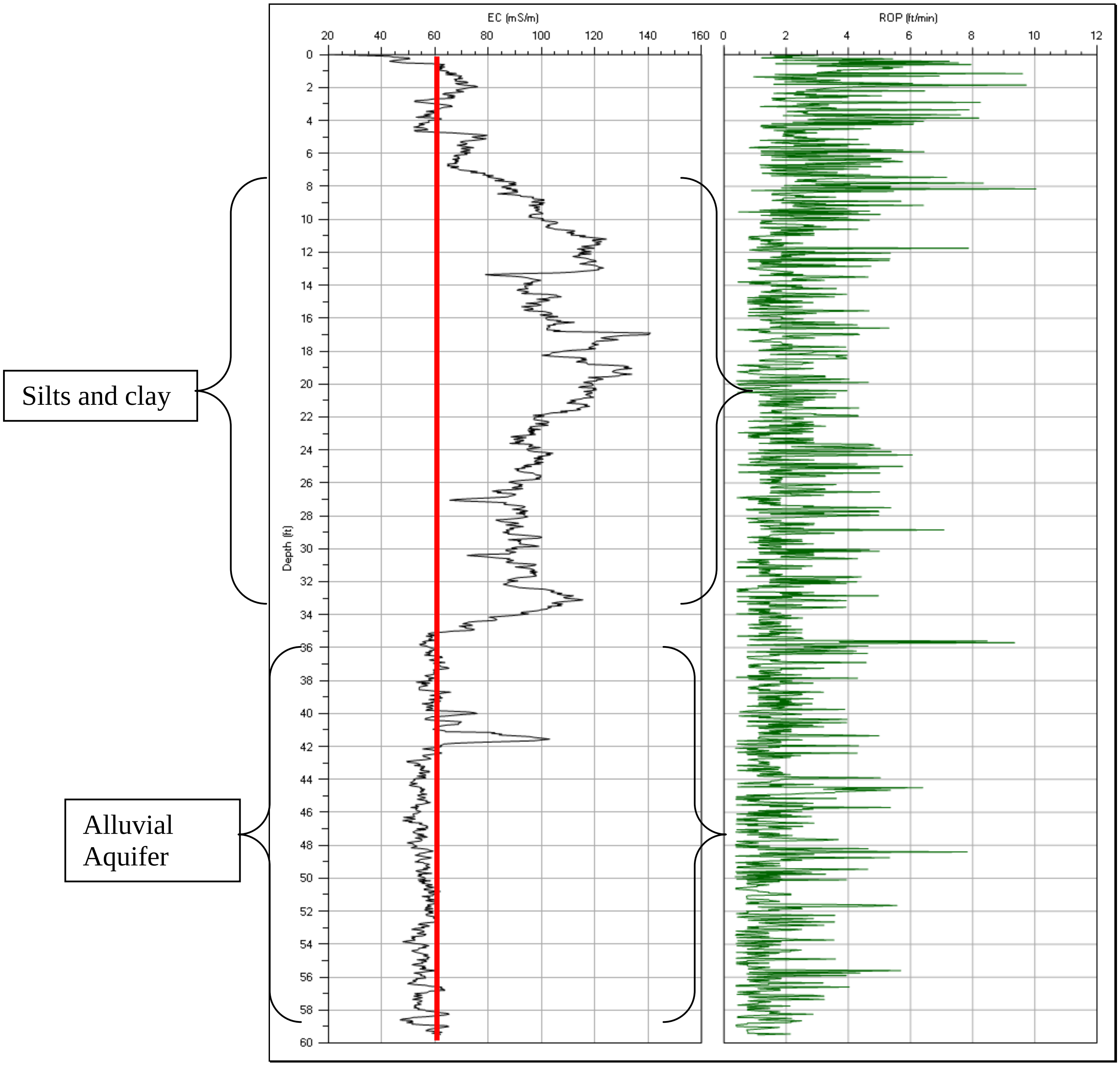
State Hygienic Laboratory Analyses for Surface Water, Soil and Ground Water

Appendix 2:

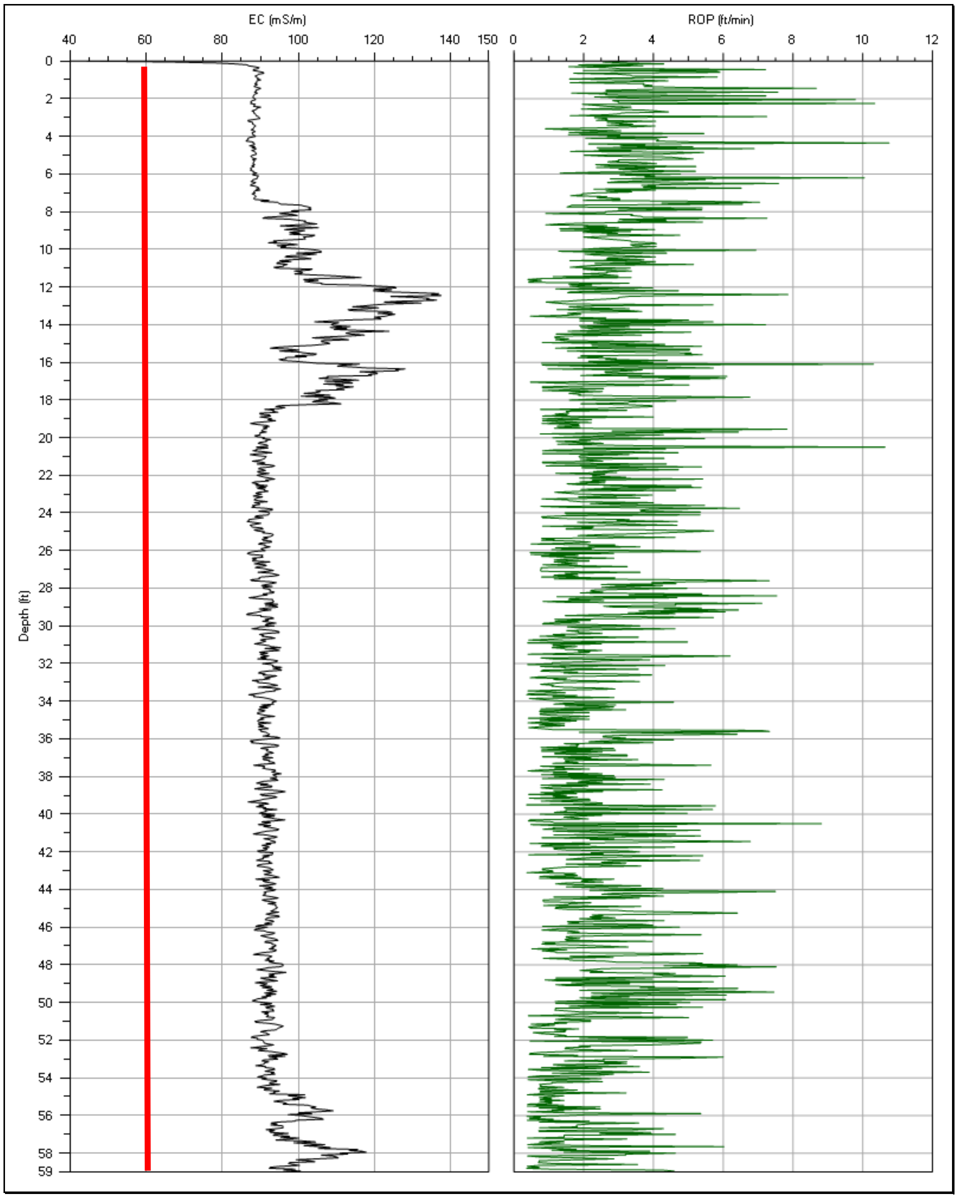
Electrical Conductivity Profiles



EC 1: Low relative EC (<60mS/m left of red line)
Aquifer indicated at 32-60 feet



EC East: Low relative EC (<60mS/m left of red line) and similar to EC1
Aquifer indicated 36 -60 feet



EC North: high relative electrical conductivity (>60mS/m)
Poor aquifer indicated

Attachment

Use of Numerical Modeling to Evaluate the Quantity and Quality of Induced Surface Water Recharge for the City of Dunlap

Prepared by
Richard Langel, Geologist
J. Michael Gannon, Hydrogeologist